

## PATENT ABSTRACTS OF JAPAN

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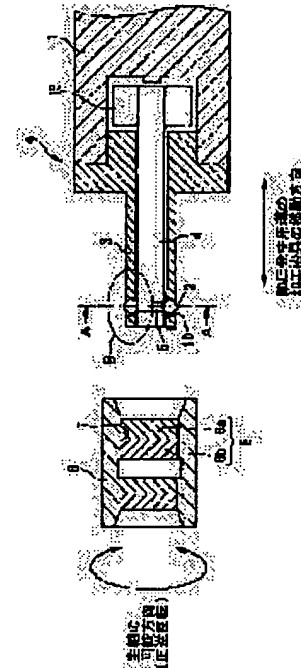
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OTSUBO TAKENOBU**(54) MACHINING JIG OF GROOVE FOR GENERATING DYNAMIC PRESSURE****(57)Abstract:**

**PROBLEM TO BE SOLVED:** To provide a machining jig capable of machining a highly precise groove for generating dynamic pressure and being manufactured at high mass productivity.

**SOLUTION:** This machining jig 9 comprises an outer cylinder 3 having a plurality of holes 10, a core pin 4 inserted in the outer cylinder 3 via a space in the radial direction, and balls 2 arranged in the holes 10. The holes 10 are provided continuously in the circumferential direction of the outer cylinder 3 piercing the outer cylinder in the radial direction, and a circumferential groove 5 having a recessed surface 5a of the radius R of curvature larger than the radius of the balls 2 is provided in a part in contact with the balls 2 of the outer circumferential surface of the core pin 4.

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## CLAIMS

## [Claim(s)]

[Claim 1] While having the outer case which has two or more holes, the core pin inserted in this outer case through the clearance between the directions of a path, and the ball arranged in said hole Said hole is the processing fixture of the slot for dynamic pressure generating characterized by penetrating said outer case in the direction of a path, being arranged and prepared in the hoop direction of said outer case, and preparing further the circumferential groove which has the concave surface of larger radius of curvature than the radius of said ball into the part which said ball touches among the peripheral faces of said core pin.

## DETAILED DESCRIPTION

## [Detailed Description of the Invention]

## [0001]

[Field of the Invention] This invention relates to the processing fixture of the slot for dynamic pressure generating on the hydrodynamic bearing.

## [0002]

[Description of the Prior Art] As a processing fixture of the conventional slot for dynamic pressure generating, the thing of a publication is in JP,11-93954,A, for example. First, the structure of the processing fixture of this slot for dynamic pressure generating is explained, referring to drawing 5 and 6. Drawing 5 is drawing of longitudinal section of the processing fixture of the conventional slot for dynamic pressure generating, and drawing 6 is the C-C line sectional view of drawing 5 .

[0003] The sleeve 6 is being fixed to the main shaft (not shown) of an engine lathe,

and normal rotation and an inversion are possible for this main shaft. When the processing fixture 9 is attached in the cutting tool base (not shown) of said engine lathe movable to the shaft orientations of said main shaft on the other hand and a cutting tool base moves, the processing fixture 9 is movable to shaft orientations. The processing fixture 9 is equipped with the core pin 4 which carries out movable in shaft orientations and the direction of a path, the outer case 3 which fits into a core pin 4 through the clearance between the directions of a path, and the ball 2 arranged in the hole 10 (refer to drawing 6 ) of the direction of a path established in the hoop direction three places at equal intervals at said main shaft side point of an outer case 3, respectively to the supporter 1 for fixing to a cutting tool base. The flange 15 for an omission stop is formed in the edge by the side of the supporter 1 of a core pin 4. And the outer case 3 is being fixed to the supporter 1. In addition, it is the hole which penetrates an outer case 3 in the direction of a path in the hole 10 of the direction of a path. Moreover, a ball 2 is harder than a sleeve 6, and a core pin 4 is hardness comparable as a ball 2.

[0004] And only the predetermined dimension is enlarged from the bore of the sleeve 6 which performs recessing for the diameter of circle [ edge / of two or more balls 2 in contact with total 4, i.e., the core pin, of the diameter of a core pin 4, the diameter of one ball 2, and the diameter of the ball 2 of another side / of the outside of the direction of a path / method ] centering on the axial center of the epilogue core pin 4. Next, the above processing fixtures of the slot for dynamic pressure generating explain how to perform recessing to a sleeve 6.

[0005] After rotating said main shaft normally, the processing fixture 9 is moved to shaft orientations toward said main shaft, and the outer case 3 of the processing fixture 9 is inserted in a sleeve 6. Although the pressure welding of

the ball 2 will be carried out to the bore side 7 of a sleeve 6, moving an outer case 3 to shaft orientations is continued as it is. Since screw motion of an outer case 3 and the ball 2 will be relatively carried out to a sleeve 6 when it does so, spiral slot 8a is formed in the bore side 7 of plastic working by ball rolling.

[0006] Next, after reversing said main shaft, when it moves to shaft orientations toward said main shaft, an outer case 3 and a ball 2 will carry out screw motion of the processing fixture 9 to the above relatively [ hard flow ] to a sleeve 6. Consequently, with the above, spiral slot 8b of hard flow is formed of plastic working by ball rolling. In the bore side 7 of a sleeve 6, spacing is set at shaft orientations, and plastic working of the slot 8 for dynamic pressure generating is carried out to two places by such actuation.

[0007]

[Problem(s) to be Solved by the Invention] However, in the processing fixture of the above conventional slots for dynamic pressure generating, the core pin 4 is cylindrical and the peripheral face is a cylinder side. Therefore, the ball 2 and the core pin 4 touch in convexes (the spherical surface and cylinder side), and this contact section serves as point contact mostly. Since the planar pressure of the contact section became large when it was point contact, the ball 2 deformed during recessing, a ball 2 may stop having rotated smoothly and the problem of being processed after the slot for dynamic pressure generating has lain in a zigzag line might arise. Moreover, since problems, like a ball 2 can be broken arose when the worst, it is in the middle of processing, it will be necessary to exchange the processing fixture 9, and the problem was in mass-production nature.

[0008] Then, the trouble which the processing fixture of the above conventional

slots for dynamic pressure generating has is solved, and this invention can process the slot for dynamic pressure generating where precision is high, and makes it a technical problem for mass-production nature to offer the processing fixture of the high slot for dynamic pressure generating moreover.

[0009]

[Means for Solving the Problem] In order to solve the above-mentioned technical problem, this invention consists of the following configurations. Namely, the processing fixture of the slot for dynamic pressure generating on this invention While having the outer case which has two or more holes, the core pin inserted in this outer case through the clearance between the directions of a path, and the ball arranged in said hole It is characterized by for said hole penetrating said outer case in the direction of a path, putting in order and establishing it in the hoop direction of said outer case, and preparing further the circumferential groove which has the concave surface of larger radius of curvature than the radius of said ball into the part which said ball touches among the peripheral faces of said core pin.

[0010] Thus, since the circumferential groove which has a concave surface into the part which said ball touches among the peripheral faces of said core pin was prepared, the convex (spherical surface) of said ball and the concave surface of said circumferential groove will touch. That is, said ball and said core pin serve as field contact instead of point contact. therefore, the planar pressure of this contact section is markedly boiled compared with the case where convexes contact, and becomes small.

[0011] Consequently, since a ball hardly deforms plastically during recessing, a ball stops rotating smoothly and there is no possibility that the problem of being

processed after the slot for dynamic pressure generating has lain in a zigzag line may arise. Moreover, since there is nothing, it is that problems, like a ball can be broken during processing arise in the middle of processing, and it hardly needs to exchange the processing fixture of the slot for dynamic pressure generating, and it is very high. [ of mass-production nature ]

[0012]

[Embodiment of the Invention] The gestalt of operation of the processing fixture of the slot for dynamic pressure generating concerning this invention is explained to a detail, referring to a drawing. In addition, this invention is not limited to this operation gestalt. Drawing 1 is the partial (outer case 3 was omitted) enlarged drawing which drawing of longitudinal section of the processing fixture 9 of the slot for dynamic pressure generating of this operation gestalt and drawing 2 expanded the A-A line sectional view of drawing 1 , and drawing 3 expanded the ball 2 and the core pin 4 among B parts of drawing 1 , and was shown. In addition, in drawing 1 -3, the sign same into a corresponding part identically to drawing 5 as drawing 5 is attached.

[0013] First, the structure of the processing fixture 9 of the slot for dynamic pressure generating of this operation gestalt is explained. The sleeve 6 is being fixed to the main shaft (not shown) of an engine lathe. Normal rotation and an inversion are possible for this main shaft. On the other hand, the processing fixture 9 of the slot for dynamic pressure generating is attached in the tool post (not shown) of said engine lathe movable to the shaft orientations of said main shaft, and the processing fixture 9 of the slot for dynamic pressure generating is movable to shaft orientations by motion of tool post.

[0014] The processing fixture 9 of the slot for dynamic pressure generating is

equipped with the outer case 3 which has two or more holes 10, the thin and long core pin 4 inserted in an outer case 3 through the clearance between the directions of a path, the ball 2 arranged in the hole 10, and the supporter 1 with which the outer case 3 was fixed. As mentioned above, the clearance between the directions of a path intervenes between the peripheral face of a core pin 4, and the bore side of an outer case 3. Since the thin and long core pin 4 can be freely moved in the direction of a path by the clearance of the direction of a path from this, even when the axial center of the bore of a sleeve 6 and the outer-diameter side of an outer case 3 has not agreed, it aligns the location of the direction of a path of a ball 2 automatically, and the depth of the slot 8 for dynamic pressure generating processed with a ball 2 serves as homogeneity. In order to make it easy to make the axis of a core pin 4 to a sleeve 6 agree, the clearance between said directions of a path has 0.01 desirablenmm or more.

[0015] Moreover, the edge by the side of the supporter 1 of a core pin 4 has the flange [ major diameter / sections / other ] 15, and has countered through the clearance between shaft orientations with both the as slight flat surfaces of a flange 15 as the end face of an outer case 3 and a supporter 1. Moreover, the peripheral face of a flange 15 has countered through the inner skin of a supporter 1, and the clearance between the directions of a path. And the core pin 4 has become movable by the clearance of said shaft orientations to the outer case 3 at shaft orientations, and is movable in the direction of a path by the clearance of said direction of a path. In addition, since a core pin 4 is good if it moves in the direction of a path freely and does not escape from an outer case 3, the structure of a flange 15 is not limited to this operation gestalt.

[0016] The hole 10 has penetrated the outer case 3 in the direction of a path, and

is established in the edge by the side of said main shaft of an outer case 3 (it is the opposite side in a supporter 1). Moreover, three holes 2 are formed, are arranged in one train and arranged at equal intervals in the hoop direction of an outer case 3 (refer to drawing 2 ). And in the hole 10, the ball 2 is arranged through clearance, and a ball 2 can be freely rotated now in a hole 10.

[0017] In addition, although the number of balls 2 should just be two or more, three pieces are desirable when the inside diameter of a sleeve 6 is 10mm or less. Since a core pin 4 will be guided with three balls 2 when the number of balls 2 is made into three pieces, the alignment nature of a core pin 4 improves. Moreover, if it is the case where there are three balls 2 even when there is only a ball of the limited dimension, the slot 8 for dynamic pressure generating of the desired depth can be formed by changing the dimension of one piece or 22 of three balls 2.

[0018] Moreover, the circumferential groove 5 which has concave surface 5a of the larger radius of curvature R than the radius of a ball 2 into the part which a ball 2 touches among the peripheral faces of a core pin 4 is formed, and the ball 2 and the core pin 4 are carrying out field contact by concave surface 5a of a circumferential groove 5. By this, planar pressure of the contact section of the ball 2 at the time of processing the slot 8 for dynamic pressure generating and a core pin 4 can be made small.

[0019] The result of having calculated the planar pressure of the contact section of a ball 2 and a core pin 4 is shown in drawing 4 . The axis of ordinate in the graph of drawing 4 is the planar pressure of the contact section of a ball 2 and a core pin 4, and an axis of abscissa is ratio  $R/D$  (radius-of-curvature ratio) of the diameter D of a ball 2, and the radius of curvature R of concave surface 5a. In addition, the relative value which set planar pressure in case said



radius-of-curvature ratio is 0.5 to 1.0 shows said planar pressure.

[0020] Planar pressure is small, so that a graph may show and a radius-of-curvature ratio approaches 0.5. If a radius-of-curvature ratio exceeds 3, since the effectiveness which the difference was lost not much with planar pressure in case the core pin 4 is not equipped with the circumferential groove 5 (for example, said conventional example), and formed the circumferential groove 5 will become scarce, as for a radius-of-curvature ratio, three or less are desirable, and one or less is more desirable. And only the predetermined dimension is enlarged from the bore of the sleeve 6 which performs recessing for the diameter of circle [ edge / of two or more balls 2 in contact with total 4, i.e., the core pin, of the diameter of a core pin 4, the diameter of one ball 2, and the diameter of the ball 2 of another side / of the outside of the direction of a path / method ] centering on the axial center of the epilogue core pin 4. If this total is enlarged, it is possible to enlarge the depth of the slot 8 for dynamic pressure generating.

[0021] Next, the processing fixture 9 of the above slots for dynamic pressure generating is used, and how to perform recessing to a sleeve 6 is explained. After rotating introduction and said main shaft normally, the processing fixture 9 of the slot for dynamic pressure generating is moved to shaft orientations toward said main shaft, and the outer case 3 of the processing fixture 9 of the slot for dynamic pressure generating is inserted in a sleeve 6. Although the pressure welding of the ball 2 will be carried out to the bore side 7 of a sleeve 6, moving an outer case 3 to shaft orientations is continued as it is. Since screw motion of an outer case 3 and the ball 2 will be relatively carried out to a sleeve 6 when it does so, spiral slot 8a is formed in the bore side 7 of plastic working by ball rolling.

[0022] If spiral slot 8a is formed, rotation of said main shaft and migration of the

shaft orientations of the processing fixture 9 of the slot for dynamic pressure generating will be suspended. Next, after reversing said main shaft, when it moves to shaft orientations toward said main shaft, an outer case 3 and a ball 2 will carry out screw motion of the processing fixture 9 of the slot for dynamic pressure generating to the above relatively [ hard flow ] to a sleeve 6. Consequently, with the above, spiral slot 8b of hard flow is formed of plastic working by ball rolling.

[0023] In the bore side 7 of a sleeve 6, spacing is set at shaft orientations, and plastic working of the slot 8 for dynamic pressure generating is carried out to two places by such actuation. Since the number of the slot 8 for dynamic pressure generating established in the bore side 7 of a sleeve 6 can measure an inside diameter with the two-point contact process by the sensing pin by inspection between processes, even 6, 12, and 18 are desirable so that the part of the crest of a slot may be arranged in the location (location of 180 degrees) where a bore counters.

[0024] In addition, forward inverse rotation of the main shaft of said engine lathe and migration to the shaft orientations of the slide which attached the processing fixture 9 of the slot for dynamic pressure generating in tool post may be performed controlling by an NC unit etc., and may be performed manually. Moreover, although processing of the slot 8 for dynamic pressure generating may be performed on an engine lathe as mentioned above, the recessing machine of dedication may perform after the completion of lathe turning. Thus, there are few possibilities that the problem of the planar pressure of the contact section of a ball 2 and a core pin 4 being small, and being processed after a ball 2 stops having rotated smoothly and the slot 8 for dynamic pressure generating has lain

in a zigzag line since a ball 2 hardly deforms plastically during recessing may arise if the slot 8 for dynamic pressure generating is processed, and it is possible to process the slot for dynamic pressure generating where precision is high.

[0025] Moreover, since there is nothing, it is that problems, like a ball 2 can be broken during processing arise in the middle of processing, and it hardly needs to exchange the processing fixture 9 of the slot for dynamic pressure generating, and it is very high. [ of mass-production nature ] in addition, this operation gestalt -- setting -- a core pin 4 -- hardening steel, such as SUJ2 and high-speed steel, -- it is superhard, it is constituted and the ball 2 consists of SUJ2, superhard, silicon nitride, a zirconia, etc.

[0026] When it constitutes a ball 2 from an ingredient with silicon nitride, a hard zirconia, etc. and a big crushing load, it is superhard and the thing also with a core pin 4 high [ hardness ] to constitute is desirable. Moreover, if the superhard core pin 4 is used, since hardness is high compared with the core pin 4 of hardening steel, a core pin 4 will hardly be deformed plastically. Consequently, since the depth of the slot 8 for dynamic pressure generating processed does not change, the slot 8 for dynamic pressure generating of the fixed depth can be formed over a long period of time.

[0027] However, when a core pin 4 and a ball 2 are superhard and are constituted, since the hardness of a core pin 4 and a ball 2 is equal, there is a possibility that a ball 2 may break. Therefore, it is more desirable than the hardness of a core pin 4 to make the hardness of a ball 2 high. That is, when it constitutes a core pin 4 from hardening steel, it is desirable to use superhard, silicon nitride, a zirconia, etc. as an ingredient of a ball 2. Moreover, when it is superhard and constitutes a core pin 4, it is desirable to use an ingredient with a crushing load for it to be

harder superhard [ silicon nitride, a zirconia, etc. ], and big for a ball 2.

[0028] Thus, since a ball 2 does not break and a ball 2 hardly deforms plastically when hardness of a ball 2 is made harder than a core pin 4, a ball 2 stops rotating smoothly, and the slot 8 for dynamic pressure generating lies in a zigzag line, and it is hardly processed. Moreover, since a ball 2 does not break, it is not necessary to exchange the processing fixture 9 of the slot for dynamic pressure generating during processing, and mass-production nature is very high.

[0029] Moreover, although the processing fixture 9 of the slot for dynamic pressure generating of this operation gestalt was equipped with the core pin 4 which has a circumferential groove 5, when a core pin 4 is constituted from hardening steel and it constitutes a ball 2 from superhard \*\*\*\*\*, it does not need to form a circumferential groove 5 in a core pin 4 from the beginning. That is, by performing actuation of performing recessing to the sleeve of a dummy with a slightly large inside diameter beforehand, plastic deformation of the core pin 4 with low hardness is carried out, and a circumferential groove (concave surface) is formed in a core pin 4. After that, a required circumferential groove can be formed in a core pin 4 by performing actuation of performing recessing, bringing the inside diameter of a sleeve close to the thing of normal gradually. If a circumferential groove is formed in a core pin 4 and recessing is carried out to the bore side 7 of the sleeve 6 (thing of the inside diameter of normal) to give the slot 8 for dynamic pressure generating, the same effectiveness as the above can be acquired.

[0030] However, since a circumferential groove is formed in a core pin 4 of plastic deformation by carrying out recessing to a dummy sleeve in this case, as for a core pin 4 or a ball 2, only the part into which a circumferential groove is

processed needs to use the big thing of a dimension. Furthermore, as a work piece which gives the slot 8 for dynamic pressure generating, a sleeve item like this operation gestalt is sufficient, and you may be the unit with which a sleeve and housing were united. Moreover, especially the quality of the material of a sleeve 6 is not limited, and a copper alloy, stainless steel, a sintered metal, a sintering oil impregnation metal, etc. are raised.

[0031]

[Effect of the Invention] as mentioned above, since the processing fixture of the slot for dynamic pressure generating on this invention prepared the circumferential groove which has a concave surface into the part which a ball touches among the peripheral faces of a core pin, its planar pressure of the contact section of a core pin and a ball is alike and small compared with the case where convexes contact. Consequently, since a ball hardly deforms plastically during recessing, there are few possibilities that the problem of being processed after a ball stops having rotated smoothly and the slot for dynamic pressure generating has lain in a zigzag line may arise, and it is possible to process the slot for dynamic pressure generating where precision is high.

[0032] Moreover, since there is nothing, that problems, like a ball can be broken during processing arise hardly needs to exchange the processing fixture of the slot for dynamic pressure generating in the middle of processing, and it is very high. [ of mass-production nature ]

## DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is drawing of longitudinal section showing 1 operation gestalt of

the processing fixture of the slot for dynamic pressure generating on this invention.

[Drawing 2] It is the A-A line sectional view of drawing 1 .

[Drawing 3] It is the partial enlarged drawing of B part of drawing 1 .

[Drawing 4] It is the graph which shows correlation with a radius ratio and planar pressure.

[Drawing 5] It is drawing of longitudinal section showing the structure of the processing fixture of the conventional slot for dynamic pressure generating.

[Drawing 6] It is the C-C line sectional view of drawing 5 .

[Description of Notations]

2 Ball

3 Outer Case

4 Core Pin

5 Circumferential Groove

5a Concave surface

8 Slot for Dynamic Pressure Generating

9 Processing Fixture of Slot for Dynamic Pressure Generating

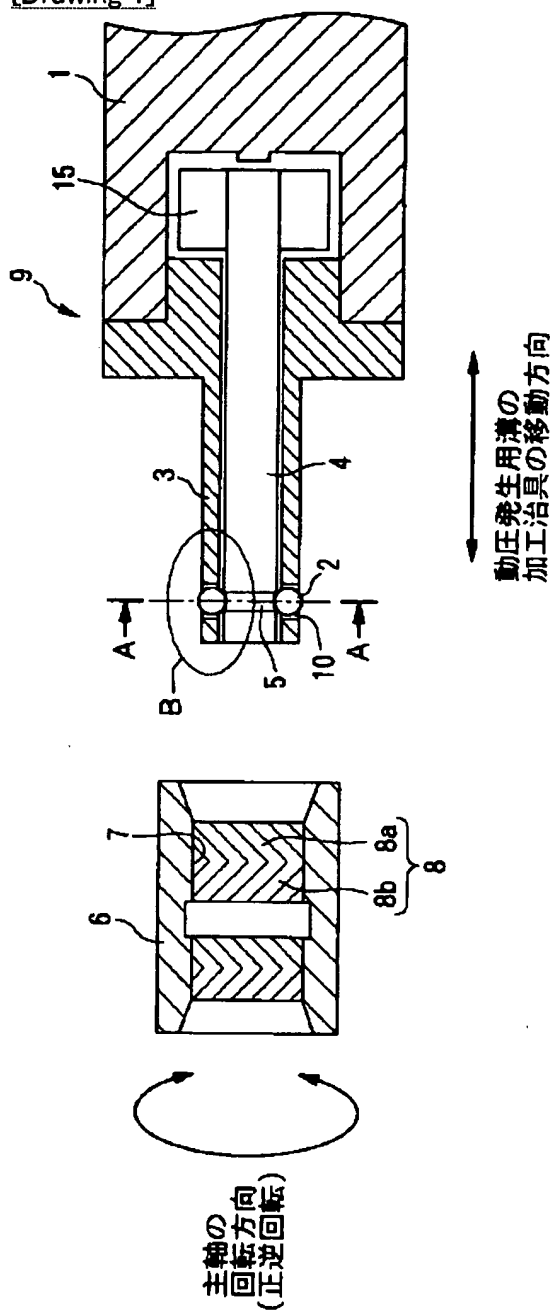
10 Hole

D The diameter of a ball

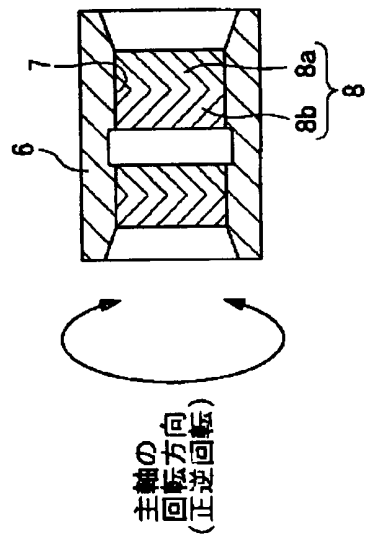
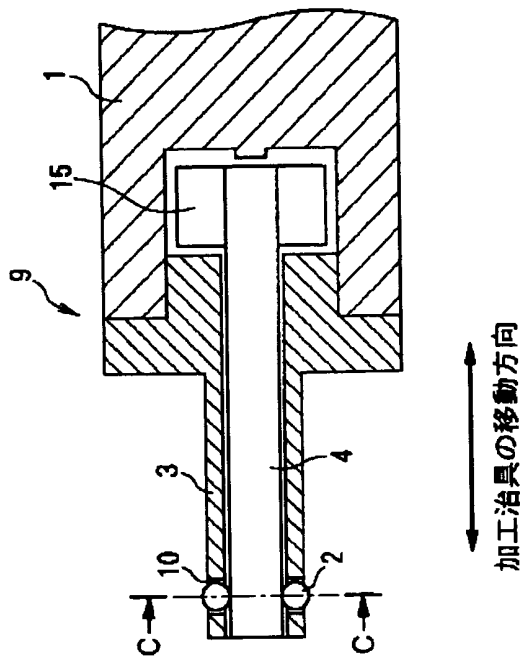
R Concave radius of curvature

## DRAWINGS

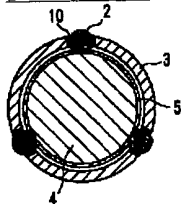
**[Drawing 1]**



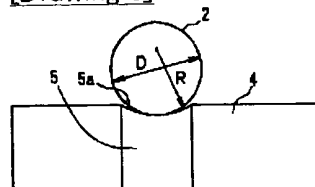
**[Drawing 5]**



[Drawing 2]

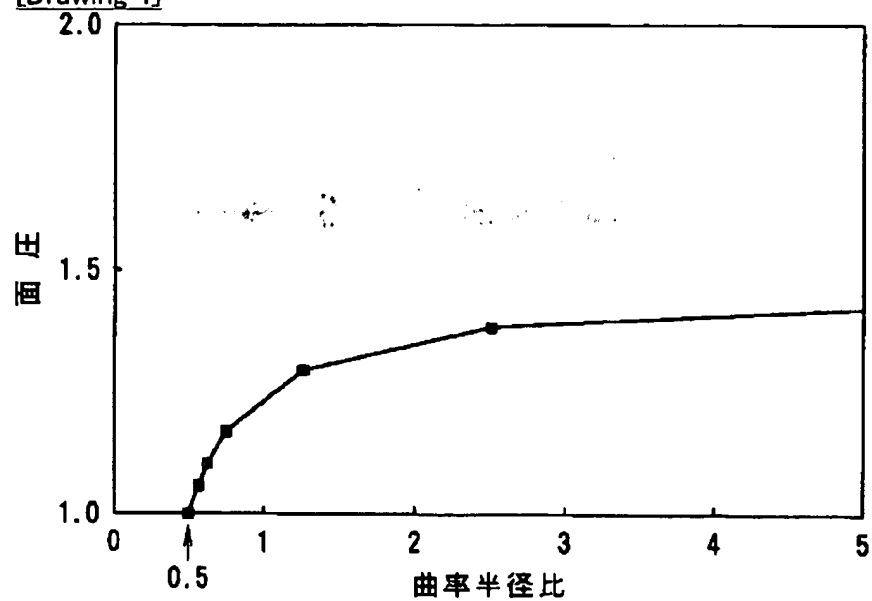


[Drawing 3]

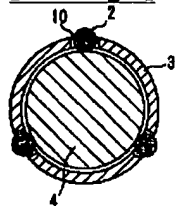




[Drawing 4]



[Drawing 6]



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